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ABSTRACT

Diversity and attitudes, skills and knowledge are the issues that need to be addressed regarding the professional development of science teachers in order to achieve scientific literacy for all in science education. Unfortunately, there is a gap between knowledge and practice in professional development initiatives. This paper describes practices and issues in the professional development of science teachers from a global perspective. (YDS)

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A COMPARITIVE ANALYSIS OF SCIENCE TEACHER EDUCATION IN GLOBAL COMMUNITIES

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As we enter the 21st century, several issues needto be addressed if we are to provide professional development for science teachers that is successful, appropriate, effective and have a long term effect. The first issue is diversity – the need to educate an increasingly diverse student population with different cultural perspectives, experiences and expectations of education, different styles of learning and behavior, and parents who bring differing views of teaching and learning to our schools.

Another major issue is enhanced goals as proposed by national standards and the global move supported by the UN at the Beijing conference towards scientific literacy for all. Achievements of these goals require that teachers know their subjects in-depth and know how to teach them to diverse learners. The attitudes skills and knowledge required by teachers to achieve this new vision for science education is both broad and deep requiring science teacher educators to re-evaluate their models for professional development, since clearly the traditional models for professional development are inadequate for helping teachers to achieve the goals of scientific literacy for all.

As noted by Loucks-Horsley et al. The current state of professional development includes:

(a) Significant numbers of teachers who have few or no professional development opportunities;

(b) A large percentage of the opportunities in the form of workshops, courses, and institutes that may not be appropriate to the learning goals or provide sufficient support over time for teachers to apply what is learned in classrooms;

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(c) A focus on individual development, one teacher at a time, without attention to organization development; and

(d) Some pockets of innovation but with minimum means for greater impact both within their own system and beyond. (Loucks-Horsley, et al. 1998).

Designing and implementing meaningful, effective professional development initiatives for science education is complex and fraught with many barriers and pitfalls. However, there exists a strong knowledge base and a great deal of consensus about what constitutes effective professional development, unfortunately there is a gap between knowledge and practice.

According to Loucks-Horsley et al (1998) one major reason is the lack of rich descriptions of effective programs constructed in various contexts addressing common challenges in unique ways.

Purpose

This paper is intended to provide a description of the practices and issues that arise during professional development of science teachers in a global context. It is both a description of science teacher's education models and a discussion of the issues that arise during professional development of science teachers. It provides a rich description of the socioeconomic and cultural contexts and challenges in teaching science, providing descriptions by experiences professional developers and researchers about ways in which they address the many barriers to effective professional development.

Professional development in science education is an area that has, to some extent, been investigated in isolated units in specific countries. However, we have not, as educators done a comparative analysis of what issues and perspectives arise during professional development for

the teachers. The following will provide a comparative analysis of what issues and perspectives arise during professional development for teachers of science in many parts of the world.

The paper will investigate the following questions:

- Are there differences and similarities in the way professional development is conducted in global communities?
- What are some of the contextual factors in professional development?
- What are some of the cultural issues that arise?
- Are there equity issues that have to be considered as science teacher education models evolve?
- What science teacher education models are being used globally?
- What are the measures of success?
- Are these models country specific, or can successful models be transposed from one country to another?
- How can we share our successes and alert others to the courses of our failures?

This paper will address these and other issues and will serve to expose science teacher educators to a global view of professional development and to some of the research, which has been conducted during the development of these models. Each section addresses specific issues in one or a group of countries. The authors are either science teacher educators who are residents of the country of have been involved in research studies in these countries.

A Global View of Professional Development

England and Indonesia

The role of in-service professional development of science teachers in large-scale changes in teaching practice is examined. Educational research has been remarkably successful

in showing how the fundamental work of psychologists, philosophers, and sociologists can be translated into practical classroom procedures, which improve the immediate quality of learning and the long-term effects on students' life chances. This work has, however, too often been limited to lab school experiments conducted at a few sites and has failed to take off into large-scale implementation – for example through adoption by school districts. Blame for this failure of the educational system as a whole to realize the benefits of well-researched practice may be placed on: the researchers, concerned with academic publication and moving on to the next new work, or on their failure as publicists; on the conservatism of teachers and school managers; on short-sightedness of politicians concerned more with elections a couple of years away than with benefits to the society which may not show up for 10 years; or, inevitably on lack of funding. At different times and in different places probably all of these accusations can be justified, and may be summarized as the inertia of the system, like a massive tanker whose direction cannot be changed by a few speedboats of research.

In this section the author describes two related but remote examples where a speedboat, persistence over many years and attention to publicity and multiplier effects, has systematically shifted a tanked of practice. In particular it will focus on the multiplier effect of a professional development program for teachers and for trainers in which in-service work (when a trainer goes to the teachers' class and supports the teacher as he or she introduces new teaching methods with their own pupils) plays a critical role. In Indonesia and in the UK we have been working with "inservice-onservice" models of professional development of teachers for nearly twenty years.

It proves to be a powerful model for effective professional development, since it overcomes the well-known problems of transferring skills learned in a professional development center to the actual classroom. There is, however a number of problems associated with the

system. One is the cost of providing a trainer to giver personal support to each teacher in their schools, especially when schools are in remote locations (as is common in Indonesia), and another is the adequate preparation of trainers and the establishment of an effective method of coaching teachers which is neither 'inspectorial' nor simply a demonstration by the instructor of a teaching method.

The author describes more fully the form of the inservice-onservice model, and strategies for overcoming problems associated with it in Britain and in Indonesia, and also techniques for evaluating the effectiveness of the professional development in terms of improved by school students.

Canada

In this section the author focuses on the history of Science Education in Canada and the effect of language of instruction, local autonomy, religion, equalization of funding and accessibility, communication, vocationalism, and diversity on science teacher education; the effect of the TIMMS report on science teacher professional development and certification and the Pan Canadian protocol for collaboration on school curriculum informed by the vision for K-16 scientific literacy and the development of teacher education models to achieve this goal. The author examines the differences an dissimilarities in the way professional development is conducted in the provinces, the cultural and contextual factors involved in professional development. He will share successes and alert others to the causes of failure during professional development of science teachers.

England

Shortly after coming to power, the Labor government set out a plan to train 'Advanced Skills teachers' who would have a 'key role to play in raising standards by supporting and

mentoring trainee teachers and newly qualified teachers'. The UK Teacher Training Agency (TTA) has outlined five standards for subject leaders (that is to say, heads of department and primary teachers responsible for a subject) 'which set out the knowledge, understanding, skills and attributes' which 'define expertise in subject leadership and are designed to guide the professional development of teachers aiming to increase their effectiveness as subject leaders...' 'Key outcomes of subject leadership' include 'teachers who: work well together as a team; support the aims of the subject and are dedicated to improving standards of teaching and learning. The standards are difficult to make operational and unproved, particularly those relating to teacher development and should be regarded as, at best useful pointers for discussion, and at worst, as naïve and distracting state interventions. Mandatory appraisal for teachers was one strategy brought in recent years in order to make teachers observe each other and talk specifically about development. However, even its supporters in government recognized that appraisal has failed to gain universal approval in schools because it often fails to address teachers' needs adequately. The emphasis in appraisal has too often been the institution and not the individual. A second issue has been the inappropriate and inadequate nature of staff development available for teachers.

Science departments are often faced with a number of problems which are external to the school but which need to be understood by heads of departments. Firstly, school science is often perceived as a whole by outsiders who are ignorant of the differing cultures, histories and traditions of the separate sciences and of the strains placed on science departments by the move to integrate science. Secondly, teachers with a limited knowledge of science often end up teaching science, particularly to younger students in secondary schools. Thirdly, the gender

nature of science-physics has been seen as a 'masculine' subject – biology as 'feminine' – has often resulted in a gender imbalance in subject choices and in the gender mix of departments.

Germany

German scores in the middle of the field of all countries, which participated in TIMSS II and III. The fact that a country with one of the world's strongest economics is not among the upper group produced an intensive discussion about possible deficiencies within the educational system. Most comments on the TIMSS results point to a variety of reasons that could have caused this situation. For the elucidation of the main critical aspects, characteristic features of the German system of professional development in Science Education will be described and some problematic elements will be presented.

The most remarkable characteristic feature of the German system that is quite different from teacher training programs in other countries, is the great amount of subject studies students are obliged to do. Because of these demands many students need a lot of time for their studies. The average duration for physics students is 13 semesters (one semester =15 weeks). A critical point in all discussions about changes that are necessary, therefore, is the following question: What is an appropriate subject knowledge prospective teachers should have in order to be able to link this knowledge with pedagogical ideas on the one hand and to teach elementary topics in science from a high level of competence on the other? Another organizational peculiarity of the German system is the separation of a more theoretical phase of teacher education at the university (including teaching practice for eight weeks, supervised by a professor of science education) and a practical phase (2 years) that takes place in schools exclusively and in which the prospective teachers are supervised by experienced teachers without any contact with the university. This separation gives the students the chance to get deep insights into both parts of

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the required knowledge but hinders them in connecting these parts in a sufficient way. These problems and other aspects of the German science teachers education programs will be presented in greater details.

Israel, Greece, Italy and the US

A major driving force in the current effort to reform science education is the conviction of many, that it is vital for our students to develop their higher-order cognitive skills (HOCS) capacity in order to effectively function in our modern, complex science and technology-based society. This means a fundamental shift from the traditional algorithmic teaching emphasizing knowledge acquisition, to HOCS-oriented learning, focusing on critical thinking. Such a paradigm shift means a different conceptualization, and, eventually, goals of the teaching-learning process which, in turn, requires different models of science teacher education with consequential results, effects and impact on the professional development of the prospective teachers as well as their professors involved in these programs. The HOCS-motivated reform in science education has had different expressions in different communities and contexts nationally and internationally concerning some emerging key issues and contextual factors. In view of the above, we have initiated and conducted within the unique science and mathematics teacher training program of our university, a longitudinal multidimensional collaborative national and (comparative) international study focusing on the following selected key issues, directly related to teachers' professional development and the quality of their teaching accordingly:

1) Assessment: Lower-order cognitive skills (LOCS) vs. HOCS – oriented exams and examination-type preferences of prospective teachers.
2) Critical Thinking: Disposition toward- and prospective teachers' capability of critical thinking (and of their prospective students).

All of these issues and related contextual factors (e.g. local culture, testing culture, teaching tradition, educational system, accepted social norms, and measure of success) will be thoroughly discussed in view of our collaborative corresponding research finding/results (in Israel, Greece, Italy, and the US). The conclusions of our studies and implications for the professional development of science teachers, their (science and mathematics teaching) and (their) prospective students' performance will be derived and summarized, in our proposed chapter, in terms of the current trends and reform in science education worldwide. Based on the above we will argue that scoring at the upper and lower ends of the TIMMS sample has, perhaps, something to do with those factors of science teachers' professional development associated with their HOCS-related dimensions which are so crucial for a successful LOCS-to-HOCS switch in science and mathematics education.

China and U.S.

This section presents:

- A close examination of the educational training and development of science teachers in China as compared to their counterparts in the U.S>, followed by a discussion of the pedagogical approach American and Chinese teachers employ in science teaching.
- Ways in which students respond to each type of instruction and how that effects the development of their cognitive skills. Throughout this paper, case studies conducted by both American and Chinese teachers who have undergone national observations of classroom teachings will supply readers with a different perspective on the ways Chinese and American teachers view the two educational systems.

Furthermore, two senior elementary and high school science teachers who have taught for nearly twenty years under the Chinese education system will offer additional updates about the

latest changes in its academic structure. Finally, the implication of thesis studies is discussed within the context of teaching and learning, and how the information gathered from both countries could be used to achieve different educational goals.

The Philippines

Recent publication of the TIMMS report has renewed interest in conducting research on international science teacher education practices. Historically, science education research has focused on evaluating the implementation of various science education curricular projects in international settings. Little, however, has been documented to understand contextual aspects of science education in these contexts, or to question underlying assumptions, which have framed research activities.

Historical Perspectives

In the proposed section, we would explore issues associated with conducting research in international contexts regarding professional development in science teacher education. The following is an outline of topics and themes, which are explored:

Efforts to research international approaches to the professional development of science teachers are showing shifts in terms of who and what is looked at in this field of research. In this section, the authors will present an historical review of international science education research on the professional development of science teachers. A look at the kinds of issues that have received attention as well as whom and how the research has been conducted will be reviewed. For example, international research in the past has typically presented descriptions of enrollment numbers, programmatic structures, coursework or certification requirements, and curriculum implementation and evaluation reports. Until recently, much of the research was conducted using large-scale quantitative methods reflective of a positivistic research tradition. The

historical summary will serve an important backdrop for discussion in a following section, which highlights research practices and assumptions, associated with current research.

Science Education Research in Today's Global Contexts

In this section, science educators from the US and Philippines pose several key questions regarding international research supported by examples from their experiences working abroad. One possible question to be explores is: How do we translate international research into culturally relevant practice? Possible issues subsumed in this category that we may want to examine are: internationalization of teacher education professional development curriculum; understanding dimensions of teacher and student learning (e.g. sociocultural, historical, personal, and epistemological influences). An example can be seen where researchers want to investigate the extent to which scientific literacy is promoted through science education in schools. In one country, scientific literacy is seen as critically important toward maintaining democracy; yet, in another apart of the world, scientific literacy represents a cultural threat to an indigenous population.

Implications for Developing Global Models for the Professional Development of Science Educators

Considering the dilemmas presented in the preceding sections, we explore a fundamental question in this section: What does it mean to develop global models for science teacher professional development? We suggest that the development of such models needs to center around the negotiation of purposes served, and cultural issues associated with science education in the local setting. We will describe possible approaches for negotiating professional development and research activities with collaborating partners.

Trinidad and Tobago

This section critically examines efforts at the professional development of science teachers in the developing country of Trinidad and Tobago. It briefly outlines the mainstream professional development opportunities for teachers at the primary and secondary levels of the system. The contextual and other factors that have helped to keep this approach to the professional development of science teachers intact over decades are critically assessed. The author describes two innovations that were not mainstream activities but were initiated in an attempt to expose teachers more directly to some of the newer approaches to science teaching that were deemed to be relevant tot he local context. The primary science teacher initiative was mounted by a UN agency with financial support from other agencies. The main aim of this professional development program was to expose teachers to strategies for using the natural tropical environment to develop lesson plans and to teach several aspects of primary science. Emphasis was placed on integration across the curriculum. The secondary science teacher initiative was funded by a UN agency and was mounted by the School of Education. The overall goal of professional development was to expose the science teachers to the procedures for designing, producing, and using contextualized science-teaching materials. The specific strategy for producing contextualized materials was adapted from methods used by a foreign consultant (Lubben) and his co-workers in a similar situation in Swaziland (Lubben, Campbell & Dlamini, 1996). Science teachers are very enthusiastic about this model of professional development. They have devised additional objectives for the official curriculum document that they consider to be essential if the science taught is to be relevant to the students' lives. They have included materials that they would not normally use in their teaching, but which they now realize are truly part of students' everyday experiences. For example, in the unit on water, they have included

lessons on the reasons why some people do not receive tap water and the efficacy of a truck borne water supply system. In the unit on maintaining health, they have designed lessons on the impact of excessive noise from discotheque music and the music of the steel band (the national instrument) on one's hearing. The impact of this method of professional development of science teachers is being monitored as the lessons are piloted. One benefit that is obvious at this stage is that teachers have begun to open up their thinking with respect to making the science taught relevant to the local context. This section will provide further details of developing this professional development model and will highlight some of the issues involved in the education of science teachers in Trinidad and Tobago and discuss a new direction that holds some promise. The author will also discuss the contextual issues that arose during the introduction of a new model for professional development of science teachers. The section culminates with an exploration of the dynamics of introducing these two innovations, with some emphasis on successes and failure. Finally the author examines the level of continuity and the feasibility of making such programs available to a wider cross section of science teachers.

Large Urban, Multicultural, Multilingual US Communities

In this section, the author reflects on a university program for preparing American science teachers to teach in large, urban, multicultural, multilingual communities among students who often belong to cultures which are foreign to the teachers; the contextual setting in which the program was developed and taught, and lessons learned while teaching the courses in the program over a ten-year period. The program was designed to empower science teachers to cope with the continuously evolving diversity in their classes while increasing interest and achievement in science. The overarching goal of the program was to increase the ability of teachers to create inclusive classrooms in which all students can learn science. Because of the

success rate of the program it is now being used as a science teacher education model in another large urban school district. It is hoped that faculty at other teacher education institutions and teacher enhancement staff developers who are grappling with how to better sensitize teachers to issues of diversity while improving the teaching and learning of science and mathematics will find this useful. This section will describe the development of this model and provide answers to the following questions as the author reflects on her experience in science teacher education in the Caribbean, the US and with UNESCO.

Conclusion

This final section highlights the major lessons learned in the professional development of science teachers and will provide a summary analysis of what issues and perspectives arise during professional development for teachers of science in the global community. The author reflects on the differences and similarities in the way professional development is conducted in global communities; the contextual and cultural issues that arise, and the successes and inherent failures of some models.

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